Spotfin Chub
Erimonax monachus

5-Year Review:
Summary and Evaluation

Spawning male
(specimen depicted as actual maximum size of 4.3 inches)

U.S. Fish and Wildlife Service
Asheville, North Carolina, Field Office

August 2014

5-YEAR REVIEW
Spotfin Chub (*Erimonax monachus*)

I. GENERAL INFORMATION

A. Methodology Used to Complete the Review

Public notice was given in the Federal Register and a 60-day comment period was opened in 2009 (74 FR 31972–31973). Pertinent status data was obtained from the Recovery Plan (U.S. Fish and Wildlife Service [FWS] 1983; hereafter not cited but referred to simply as "Recovery Plan"), published papers, unpublished reports, museum records, state natural resource agency imperiled species databases, and personal communications from governmental biologists, private consultants, and other experts on Spotfin Chub. Once all known and pertinent data was gathered for this species, the status information was compiled and the review was completed in its entirety by the species' recovery lead biologist in the Asheville, North Carolina, Field Office (FO). A draft of the 5-Year Review was peer reviewed by five experts familiar with the species (see Appendix A for a summary of the peer review). In addition, the draft was sent to FWS endangered species biologists throughout its historical range for their comments.

B. Reviewers

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C. Background

1. **FR Notice citation announcing initiation of this review:** July 6, 2009:

74 FR 31972

2. **Species status:** Stable (August 2013)

3. **Recovery achieved:** 1 (0–25%), 2013

4. **Listing history**

<u>Original Listing</u>
FR notice: 42 FR 45527–45529
Date listed: September 9, 1977
Entity listed: Species
Classification: Threatened

5. **Associated rulemakings**:

1977. Critical habitat (designated concurrently with listing) (42 FR 45527–45529).

2002. Establishment of Nonessential Experimental Population Status and Reintroduction in Tellico River, Tennessee (67 FR 52420–52428).

2005. Establishment of Nonessential Experimental Population Status and Reintroduction in Shoal Creek, Tennessee and Alabama (70 FR 17916–17927).

2007. Establishment of Nonessential Experimental Population Status and Reintroduction in lower French Broad River and lower Holston River, Tennessee (72 FR 52433–52461).

6. **Review History**:

No 5-year reviews or other relevant documents have been previously completed on the Spotfin Chub since the Recovery Plan was finalized in 1983, though the species' status was reviewed as a part of the annual Recovery Data Call until 2011.

7. **Species' Recovery Priority Number at start of review:** 11, indicating a species with a moderate degree of threat and low recovery potential. No major changes in the species' status have occurred since the Recovery Plan was written and the recovery priority number was assigned.

8. **Recovery Plan or Outline**

Name of plan: Recovery Plan [for the] Spotfin Chub (*Hybopsis monacha* [=*Erimonax monachus*]

Date issued: November 21, 1983

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) Policy

1. Is the species under review listed as a DPS? No

2. Is there relevant new information that would lead you to consider listing this species as a DPS in accordance with the 1996 policy? No

B. Recovery Criteria

1. Does the species have a final, approved recovery plan containing objective, measurable criteria? Yes

2. Adequacy of recovery criteria.

a. Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? No

The recovery criteria do not reflect the best available and most up-to-date information on the biology of the species and its habitat for two general reasons: 1) more life history information is known primarily from the development of propagation technology and other information compiled in recent publications, 2) substantial natural population expansion has apparently occurred in the North Fork Holston River population cluster since the 1983 Recovery Plan was written and several new tributary occurrences are known from three of the four population clusters, and 3) population reintroduction efforts are underway to establish the species in three streams across its range (but see section II.C.1.a).

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)? No

3. List the recovery criteria as they appear in the Recovery Plan, and discuss how each criterion has or has not been met, citing information.

There are two explicit recovery criteria listed in the Recovery Plan, in addition to an implicit statement on elimination of threats. These three criteria are addressed below:

1. Through protection of existing populations and/or by introductions and/or discoveries of new populations there exist viable populations in the Buffalo River System, Upper Little Tennessee River, Emory River System, and Lower North Fork Holston River of the following magnitudes.

a. **Buffalo River System, Tennessee: The species persists in the Buffalo River in the area of Grinders Creek and/or some other river section.**

b. **Upper Little Tennessee River, North Carolina: The species occupies its preferred habitat throughout the approximately 32.5 kilometer (km) [20.2 river miles (RMs)] river reach from the head of Fontana Reservoir to near Franklin Dam. This can be measured by determining that the species exists at a minimum of 10 locations along this river reach.**

c. **Emory River System, Tennessee: The species occupies its preferred habitat in the Emory River from its confluence with the Obed River to Watts Bar Reservoir, in Clear Creek from its confluence with White Creek downstream to its confluence with the Obed River, and Daddy's Creek from river kilometer (RKM) 5.6 [RM 3.5] downstream to its confluence with the Obed River. This can be measured by determining that the species exists at a minimum of eight locations in the Emory River section, five locations in the Clear Creek sections, and five locations in the Daddy's Creek section.**

d. **North Fork Holston River, Tennessee and Virginia: The species occupies its preferred habitat throughout the river reach from its mouth upstream 72 kms [44.7 RMs]. This can be measured by determining that the species exists at a minimum of 15 locations along this river reach.**

The use of the vague and ill-defined term "location" for Spotfin Chub occurrences in this recovery criterion makes it somewhat subjective and not easily definable. Further, using the word "protection" in reference to streams of occurrence is similarly subjective and relative, since it is unrealistic that we could meaningfully protect all stream populations from all threats to the species.

Buffalo River: The species continues to persist in a ~9-River Mile (RM) reach of Buffalo River in the vicinity of Grinders Creek to Natchez Trace Parkway. Sampling in recent years demonstrates that the current extent of range in Buffalo River meets recovery criterion 1.a.

Little Tennessee River drainage: The species continues to persist in the entire ~23-RM reach of Little Tennessee River between Fontana Reservoir and Franklin Dam. This represents a slight increase in range from that stated in the Recovery Plan. In addition, the species is seasonally found in nearly a dozen tributaries of the main stem in this reach. Sampling in recent years demonstrates that the current extent of its range in Little Tennessee River meets recovery criterion 1.b.

Emory River drainage: The species continues to persist in these general areas, though some apparent population restrictions and expansions have been noted since the Recovery Plan was written in 1983. Spotfin Chub distribution in this population cluster contracted slightly since the recovery plan was written, though its range has expanded in Emory River and the species is now known to occur sporadically in Clifty Creek and Crab Orchard Creek near their mouths. Being more diffusely distributed in the drainage helps protect the species from stochastic events that might be more of a profound threat to a population that is more linearly distributed (see section II.C.2.e.). Due to apparent population restriction in Daddys Creek and Clear Creek since the mid-1980s, the current extent of the species' range in the Emory River drainage probably does not meet recovery criterion 1.c. However, if the total number of locations needed in this drainage (18) were considered regardless of which stream they occurred in (which would require rewriting the recovery criteria), recovery criterion 1.c. could be met with its expansion in the Emory River main stem plus two additional tributary occurrences.

North Fork Holston River drainage: The species continues to persist in this river reach and is now occasionally found considerable distances upstream and downstream compared to the early 1980s. Further, the species was discovered from the main stem Holston River in 1992 ~25 RMs downstream from the North Fork Holston River confluence. Individuals are also periodically sampled near the mouths of some tributary streams in this extended reach, one (Wolf Creek) located >25 RMs upstream of its known range in the Recovery Plan. Evidence for population expansion in recent years may indicate that recovery criterion 1.d. could be met, though more systematic sampling is needed to determine its actual range in lower North Fork Holston and upper Holston rivers and whether the species occurs at 15 localities in this combined linear reach.

In addition to the stream reaches Spotfin Chub inhabited at the time the Recovery Plan was written, the extent of the range of the species has expanded to varying degrees in all four main stems defining each population cluster. Further, there are now new tributary records in all but Buffalo River. This is particularly true in Little Tennessee River, where the species is primarily limited to the lowermost few miles of the 11 tributary streams of that river. Though this recovery criterion has not been entirely met in all four population clusters, it probably has in at least two of them. The vague term "location" needs to be better quantified to reflect the actual status of the species in these drainages.

2. Through introductions and/or discovery of two new populations there exist viable populations in two other rivers.

The Recovery Plan contains this definition: *viable populations* – Population monitoring over a ten-year period (biannual samples) indicates that the species is reproducing (at least two year classes each year sampled) and that the population is either stable or expanding.

Since the Recovery Plan was written, additional highly disjunct locations for Spotfin Chub have been reported. These include Middle Fork Holston River, Virginia (Haxo and Neves 1984), East Fork Poplar Creek, Tennessee (C.F.

Saylor, TVA retired, pers. comm., 2009, 2014), and Duck River, Tennessee (B.M. Burr, Southern Illinois University [SIU], pers. comm., in Boschung and Mayden 2004). These occurrences are outside known population clusters and isolated by impoundments (in the case of Middle Fork Holston River and East Fork Poplar Creek) and long reaches of apparently unsuitable habitat (in the case of Duck River). Specimens from North Fork Holston River sampled by Haxo and Neves (1984) are reportedly housed at Roanoke College (C.F. Saylor, TVA retired, pers. comm., 2009), but extant specimens are not known from Duck River. A 1995 TVA record from Middle Fork Holston River, Virginia is not considered valid since voucher specimens nor photos are available for substantiation (TVA database, C.F. Saylor, TVA retired, pers. comm., 2009). Though the historical occurrence of Spotfin Chub in Middle Fork Holston River is accepted as valid, the species has not been found subsequently in the river despite numerous sampling efforts over the past several decades (TVA database, C.F. Saylor, TVA retired, pers. comm., 2009), including at four sites in 2013 (Petty and Rakes 2013). This information indicates that the species may be extirpated from Middle Fork Holston River. A project to search Middle Fork Holston River for the species has been funded and is underway (M.J. Pinder, VDGIF, pers. comm., 2014). A single Spotfin Chub was sampled by Oak Ridge National Laboratory biologists in 2002 from East Fork Poplar Creek, a tributary of lower Clinch River (C.F. Saylor, TVA retired, pers. comm., 2009, 2014). The record in this stream is separated by ~31 RMs of impoundment (Watts Bar Dam on Tennessee River) to the nearest extant population in lower Emory River. Though the record is accepted as valid, it is possibly a bait bucket introduction (C.F. Saylor, TVA retired, pers. comm., 2009). For the purpose of this review, this record is omitted. Since there are no details on its purported occurrence in Duck River, the veracity of this record is questionable (P.L. Rakes, CFI, and C.F. Saylor, TVA retired, pers. comm., 2009). If current sampling efforts were to demonstrate that these or any other "new" streams harbored natural viable populations (as defined in the Recovery Plan), this criterion could be met.

Population reintroduction of cultured individuals into four streams has been attempted by recovery biologists since the late 1980s. In 1988, a partnership between CFI, Great Smoky Mountains National Park (GSMNP), Tennessee Wildlife Resources Agency (TWRA), and University of Tennessee–Knoxville (UTK) began to release translocated Spotfin Chub collected from upper Little Tennessee River into Abrams Creek, a lower Little Tennessee River tributary in GSMNP, Tennessee (Rakes et al. 2010). Beginning in 1994, artificially cultured individuals, produced at CFI, were used exclusively for the reintroduction. After ~15 years of release of translocated fish from wild populations and cultured fish, the Abrams Creek project was terminated when it failed to produce naturally-spawned Spotfin Chub (George et al. 2009). Partners (e.g., CFI, FWS, NCWRC, TWRA, UTK) have also cultured Spotfin Chub for release into three additional streams in recent years: Tellico River, Cheoah River, and Shoal Creek. Since 2002, when designated as a non-essential experimental population (NEP) reach for several fishes (67 FR 52420–52428), CFI has released ~19,000 cultured

Spotfin Chub into Tellico River, another lower Little Tennessee River tributary in east Tennessee (Petty et al. 2014). Beginning in 2007, when also designated as a NEP (70 FR 17916–17927), CFI has released ~22,000 cultured Spotfin Chub into Shoal Creek, a middle Tennessee River tributary with its headwaters in south central Tennessee that drains southward into northern Alabama (Petty et al. 2014). Since 2009, NCWRC has released ~2,200 mostly cultured Spotfin Chub juveniles into Cheoah River, a third tributary of lower Little Tennessee River in North Carolina (S.J. Fraley, NCWRC, pers. comm., 2009). Spotfin Chub in Tellico River now appears to be thriving with ample evidence of recruitment and dispersal, though the total distribution of suitable habitat appears to be limited (Petty et al. 2014; P.L. Rakes, CFI, pers. comm., 2009, 2014). The species also appears to be thriving in Cheoah River, with numerous observations in recent years of adults and juveniles both upstream and to a lesser degree downstream from the points of release (S.J. Fraley, NCWRC, pers. comm., 2014). These two populations need to continue to be monitored for several more years to determine if they truly become self-sustaining. In Shoal Creek, despite the introduction of ~22,000 individuals, very few observations have been made (Petty et al. 2014). Habitat is abundant and distributed over many miles in the watershed, and coupled with competition with other cyprinids suggests that many more years (10+) of reintroductions and monitoring may be needed to determine success in establishing a self-sustaining population in Shoal Creek (J.R. Shute, CFI, pers. comm., 2014).

Currently, this criterion has not been met but is in the process of being met in Little Tennessee River. However, if on-going monitoring (for a total of 10 years, according to recovery criteria in the Recovery Plan) of at least two of the reintroduced populations continues to display signs that they are self-sustaining, this criterion could be met.

3. [N]o present or foreseeable threats exist which would cause it be become in danger of extinction throughout a significant portion of its range.

Four distinct population clusters of Spotfin Chub defined in the Recovery Plan still persist. Due to the disjunct nature of extant occurrences caused primarily by impoundments, isolation of Spotfin Chub populations is an inherent threat to the continued existence of the species. Two of the four population clusters, Emory River and Little Tennessee River, are relatively robust but essentially occur in a total of ~35 and ~23 RMs, respectively. The North Fork Holston/Holston River cluster occurs occasionally over ~96 RMs but is much more sporadic in occurrence and not nearly as robust as the Emory River and Little Tennessee River populations. The Buffalo River population is by far the smallest and most imperiled Spotfin Chub population in existence, occurring over no more than 9 RMs and apparently linearly distributed. Each of the four population clusters is considered currently viable (but not by the definition of this term in the recovery criteria). However, relatively limited distribution in all but the Holston River drainage population cluster makes their populations increasingly susceptible to catastrophic stochastic events (see section II.C.2.e.).

Sedimentation from various sources (e.g., agriculture, mining, developmental activities, unprotected stream buffers) continues to threaten all Spotfin Chub populations. The species depends on relatively silt-free foraging and spawning habitats for survival (Sutherland 2005; Sutherland and Meyer 2007). Contaminants from industrial sites, active mining activities as well as inactive mines, and other sources also threaten Spotfin Chub in Emory River and North Fork Holston River. The species may also be affected by the habitat conditions downstream of certain dams. Spotfin Chub in Little Tennessee River may be affected by management and operation of Franklin Dam, which is in the process of renewing its Federal Energy Regulatory Commission (FERC) license. Santeetlah Dam, which is a non-hydropower facility, has been modified to improve habitat for reintroduced Spotfin Chub, the endangered Appalachian Elktoe, and other aquatic organisms in Cheoah River. The species naturally inhabits warm, upland streams, and cool temperatures were considered a limiting factor in the Recovery Plan. Some populations of the species could be threatened by climate change if future climatic conditions result in extreme flows or temperatures that exceed its tolerance thresholds.

In summary, remaining Spotfin Chub populations continue to be threatened by habitat fragmentation and population isolation, sedimentation and legacy contaminants events, and are susceptible to varying degrees by stochastic events. In reality, these threats are largely perpetual (particularly population isolation and stochastic events) and not likely to be ameliorated to any significant degree in the foreseeable future. Despite this situation, these threats are probably not close to being of a magnitude or imminence to warrant a change to endangered status for the species in the foreseeable future. Thus, this criterion could essentially be achieved.

C. Updated Information and Current Species Status

1. Biology and Habitat

Very little biological information was presented in the Recovery Plan, though detailed life history aspects were available in Jenkins and Burkhead (1982), and in other sources widely cited elsewhere in the document. Information from the report of Jenkins and Burkhead (1982), their published version of this study (Jenkins and Burkhead 1984), and other data were synthesized by Etnier and Starnes (1993), Jenkins and Burkhead (1993), and Boschung and Mayden (2004). Relevant biological information not included in the Recovery Plan and gathered from these and other sources is provided here.

Spawning Behavior

The Recovery Plan stated that reproductive behavior had not been observed. Since then, spawning behavior of Spotfin Chub has been observed in the wild (Jenkins and Burkhead 1993; Sutherland 2005). The species is a crevice spawner, selecting slots and fissure sites in bedrock or created by adjacent large boulders or boulders and bedrock. Spawning crevices are relatively silt-free and typically located in shallow runs with moderate current. Spotfin chub are polygamous but males select single crevices in which to spawn with one or more females. Males swam "solo runs" though crevices when displaying or depositing milt. Water temperature at the time of observed natural spawning varied from 26.1–27.2°C. Spawning has also been observed under hatchery conditions (Rakes et al. 1999; P.L. Rakes and J.R. Shute, CFI, pers. comm., 2009). Crevice habitat is simulated in culture facilities using clay tiles.

Early Life History
Ova are adhesive and measure 0.03–0.06 in (inches) diameter (Jenkins and Burkhead 1982, 1984). Incubation time is 6 days at 25°C. Propagation technology has been developed since the Recovery Plan was finalized (Rakes et al. 1999). Propagated Spotfin Chub need a considerable volume of water for grow-out of young-of-year to subadult or adult individuals relative to other stream fishes (P.L. Rakes and J.R. Shute, CFI, pers. comm., 2009).

Fecundity
The reported number of ova produced by individual females ranges from 157–791 (Jenkins and Burkhead 1982, 1984). Fecundity may be much higher considering the species is a fractional spawner, which indicates that females may not oviposit their entire output of eggs in a single spawning with a male (Jenkins and Burkhead 1993; Boschung and Mayden 2004).

Age and Growth
Most individuals spawn by year 2, though year 1 spawners may occur and age appears similar among sexes (Etnier and Starnes 1993; Jenkins and Burkhead 1993). Spotfin Chub live to year 3. By May, age 1 fish ranged in size from 0.8–1.9 in standard length (SL) and age 2 fish ranged from 2.2–3.5 in SL (Etnier and Starnes 1993). Males achieve larger size than females. Tuberculate males ranged from 2.4–3.5 (in SL and gravid females from 2.1–3.0 in SL (Jenkins and Burkhead 1993). Maximum reported size is 3.9 in SL and 4.3 in total length (Etnier and Starnes 1993; Boschung and Mayden 2004).

Diet and Foraging Behavior
The Recovery Plan stated Spotfin Chub to be a benthic diurnal insectivore without providing details. The species' diet is comprised of 90% immature midge (Chironomidae) and blackfly (Simuliidae) larvae, the uniform minuteness of their prey being noteworthy (Jenkins and Burkhead 1993). Caddisflies and other insect larvae also comprise the diet (Etnier and Starnes 1993). The near absence of detritus and inorganic material in their gut indicates they are sight feeders (Boschung and Mayden 2004), though caddisfly cases may appear in their guts

(Etnier and Starnes 1993). Stream observations indicate that Spotfin Chub are more benthic than most other cyprinids and feed primarily on the surfaces of boulders, bedrock, and other substrates that are largely free of vegetation or sediments. They are typically oriented at an angle downward several degrees from horizontal when foraging, move about with quick zigzag motions, remain close to the bottom, and apparently do not opportunistically take drifting insects in the water column like most other shiners. They often school with Whitetail Shiner (*Cyprinella galactura*) while foraging (pers. obs.).

Distribution
Numerous papers and reports have become available since the Recovery Plan refining the current distribution of the species. These include the Holston River drainage (CFI report pending; P.L. Rakes, CFI, pers. comm., 2014), Emory River drainage (Russ 2006), and Little Tennessee River drainage (W.T. Russ, II, NCWRC, pers. comm., 2014). Other records were provided by colleagues and recorded as personal communications in this review (see annotated stream population accounts under II.C.1.a.).

Microhabitat Use
A study by Kanno (et al. 2012) on microhabitat use of Spotfin Chub at several sites in the Emory River watershed found that the species was selective of boulder and bedrock substrates (particularly at smaller stream sites where these substrates were uncommon), medium to high velocity, and medium depths (typical of runs). It also tended to be in swifter flows during warm seasons. Overall, Spotfin Chub were somewhat flexible as to microhabitat types, and microhabitat use may change depending on macrohabitat factors (e.g., stream size, temperature). The authors thought that such refinement of microhabitat usage would benefit managers attempting to target key habitats for protection and monitoring over time.

a. Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Most literature and museum records report low population numbers for Spotfin Chub, suggesting that it has always been an uncommon species (Etnier and Starnes 1993; Jenkins and Burkhead 1993; Boschung and Mayden 2004). The specific epithet in Latin, assigned by E.D. Cope, describer of the species, translates to "unique, single, solitary" reflecting the species' apparent rareness (Etnier and Starnes 1993). Rarity in these collections could at least partially be attributable to its general occurrence in larger streams coupled with it frequenting habitats that are not easily sampled with casual collecting techniques like seining (Etnier and Starnes 1993). Most occurrences in smaller streams are considered marginal (Jenkins and Burkhead 1982, 1984). In small streams Spotfin Chub typically occurs near the mouth and the species probably depends upon a nearby source population for sustainability (e.g., lower Shoal and Little Bear Creeks with preimpounded Tennessee River as a source; Abrams Creek with preimpounded Little Tennessee River as a source; numerous tributaries of upper Little Tennessee

River) (Jenkins and Burkhead 1982, 1984). Spotfin Chub was known from three or fewer specimens from 10 mostly small streams where the species is now considered extirpated (Jenkins and Burkhead 1982, 1984).

Despite its overall rarity even in historical times, Spotfin Chub was nevertheless locally common or even abundant. The species was noted as being common at a few sites in the lower reaches of North Fork Holston River and Emory River in the 1970s and 1980s (Jenkins and Burkhead 1982, 1984) and as being abundant in South Chickamauga Creek in 1877 (Jordan and Brayton 1878).

Spotfin Chub generally is a rare species that inhabits a fraction of its historical range. Overall, none of the four population clusters was considered to be "flourishing" in the early 1980s (Jenkins and Burkhead 1982, 1984). Though currently inhabiting ~110 RMs of stream, potentially hundreds of miles of its former habitat in the Tennessee River drainage have been lost over the past century. Considering the huge loss of range, it is likely the current total population size of Spotfin Chub similarly represents a small proportion of its historical abundance. Unfortunately, very little quantifiable information is available for estimating population size for Spotfin Chub either historically or currently except by comparing the historical versus current range occupied by the species.

The Recovery Plan noted four population clusters of Spotfin Chub in Tennessee River tributary drainages: Buffalo River, Emory River, Little Tennessee River, and North Fork Holston River. Three additional records outside of these clusters have been reported since the Recovery Plan was finalized (see section II.B.3. Recovery Criterion 2). The extent of known occurrences in streams in all population clusters has apparently expanded since 1983. There are three basic reasons for this trend: 1) the potential for Spotfin Chub discovery has increased as stream sampling has expanded since the Recovery Plan was written, 2) the ability biologists have for finding the species has improved concurrent with increased sampling in Tennessee River drainage streams, and 3) there have been noticeable water quality improvements in some streams (e.g., chemical contaminant reduction in the North Fork Holston River; cleaner industrial discharges in Kingsport at the origin of the Holston River; abandoned mine recovery on a tributary Crab Orchard Creek) (C.F. Saylor, TVA retired, pers. comm., 2014).

Estimations of abundance in individual streams or population clusters are difficult to ascertain and may be of limited value in comparisons across populations. Collecting techniques, sampling effort, and whether or not collectors have prior knowledge of Spotfin Chub habitat vary widely and will greatly influence results. Quantitative snorkel surveys are probably the best means to assess population numbers. Available population data collected over ~30 years in Little Tennessee River suggest that abundance can fluctuate widely over relatively short periods of a few years (T.W. Russ, II, NCWRC, pers. comm., 2014). Factors such as widely fluctuating water levels year over year may have a significant effect upon Spotfin

Chub population levels by influencing reproductive success and recruitment. For instance, the high-water year of 2013 appears to have contributed to some of the lowest population estimates for the species in Little Tennessee River over the past seven years (T.W. Russ, II, NCWRC, pers. comm., 2014).

The following is an annotated summary of the status of Spotfin Chub in each population cluster, including information on attempted population reintroductions. Historical population information was summarized in Jenkins and Burkhead (1982, 1984). Distribution within particular streams is described in terms of being "generally distributed" (any suitable habitat should be expected to yield specimens with a reasonably thorough search), "occasional" (suitable-appearing habitat may or may not yield specimens even after prolonged search), or "sporadic" (encountering specimens cannot be predicted at all) (Smith 1965). No connotation of abundance is intended with this terminology, though relative abundance is generalized in many cases with the terms rare, uncommon, or common. Threats are briefly summarized for each population cluster. Overall status of the population cluster is generally assessed as improving, stable, declining, or unknown.

Holston River drainage, Virginia and Tennessee: Holston River, along with French Broad River, forms Tennessee River at Knoxville. Headwaters are primarily in southwestern Virginia and a small portion of western North Carolina with the lower portions of the watershed in northeastern Tennessee. Most of the Holston River drainage occurs in the Ridge and Valley Physiographic Province, though portions of South Fork Holston River including Watauga River drain the Blue Ridge Physiographic Province. Holston River proper is formed at the confluence of North Fork Holston and South Fork Holston rivers.

Prior to the 1983 Recovery Plan, Spotfin Chub was known in the Holston River drainage only from North Fork Holston River, Virginia and Tennessee, in disjunct reaches of the upper and lower river and pre-impoundment portions of the South Fork Holston River drainage. In North Fork Holston River, an ~37-RM reach downstream of Saltville, Virginia, had no records of Spotfin Chub, chemical works at Saltville having contributed huge quantities of mercury and other pollutants to the river for the better part of a century, causing fish kills and rendering habitat toxic for most aquatic organisms (Jenkins and Burkhead 1982, 1984, and citations therein). The species was lost in South Fork Holston River and upper North Fork Holston River upstream of Saltville by the 1950s, leaving only lower North Fork Holston River known to harbor the species in the Holston River drainage (Jenkins and Burkhead 1982, 1984).

At the time of the Recovery Plan, Spotfin Chub was thought to occupy the reach of lower North Fork Holston River to RM 45 (status summarized in Jenkins and Burkhead 1982 and 1984). By the early 1990s Jenkins and Burkhead (1993) considered it to be "rare or uncommon" in this drainage, though they reported that it seemed to be expanding. In 1992 the species was discovered by TVA in the

Holston River main stem at RM 118, about 25 RMs downstream of the North Fork Holston River confluence. Two individuals were also sampled at North Fork Holston River at RM 56 in 1995, extending its range upstream 11 RMs (R.B. Evans, USFWS, pers. comm., 2009). One or two individuals have since been sampled in the lower reaches of three other tributaries of North Fork Holston River: Wolf Creek at ~RM 71 in 1999 and Possum Creek at ~RM 6 in 2003, and in lower Terrill Creek, a tributary of Holston River very near where the species occurs in Holston River, in 2004 (C.F. Saylor, TVA retired, pers. comm., 2009). Importantly, discovery of Spotfin Chub in Wolf Creek appears to indicate significant population expansion in the river, the species apparently having reinvaded a section of river ~12 RMs downstream of Saltville where it had never been previously sampled. This highly polluted reach of North Fork Holston River has long been considered a barrier to dispersal of aquatic organisms.

The species is generally sporadic but locally occasional in distribution in the Holston River drainage. Abundance was reported as "generally uncommon to rare" by Jenkins and Burkhead (1980). Population size remains generally low, though sampling during 2013 indicated that the species was locally common up to ~RM 49 (P.L. Rakes, CFI, pers. comm., 2014). Its range in North Fork Holston River and Holston River has expanded substantially since the early 1980s. Distribution and abundance data tends to indicate that habitat and water quality conditions appear to be improving in the river though comprehensive census data is largely lacking. Well over half of the stream miles Spotfin Chub is currently known from rangewide are in this population cluster, though occurrences are generally sporadic in nature and total population size is small. Long pools and other areas of unsuitable habitat potentially contribute to the apparent scarcity of the species.

Threats include legacy pollution from Saltville, agricultural runoff, and sedimentation from various sources. Despite these perturbations, Spotfin Chub status has improved over the past 30 years manifest in the range expansion exhibited by the species in this population cluster and apparent increases in relative abundance.

Emory River drainage, Tennessee: Emory River is a major tributary of lower Clinch River, in the upper Tennessee River drainage. The eastern Tennessee drainage is nearly entirely located on the Cumberland Plateau Subsection of the Appalachian Plateaus Physiographic Province, with only a portion of the lowermost Emory River occurring in the Ridge and Valley Physiographic Province.

Spotfin Chub was historically known in Emory River from the confluence with Obed River (~RM 29) downstream ~16 RMs to Watts Bar Reservoir on Tennessee River, the lower ~9 RMs of Obed River from the Daddys Creek confluence downstream to its mouth at Emory River, and the lowermost 9 RMs of Clear Creek, lowermost 2 RMs of Daddys Creek, and the lower mile or so of

Indian Creek and Island Creek. No preimpoundment records are known, though the lowermost 13 RMs of Emory River likely harbored the species as well. A single individual was discovered in lower Clifty Creek, a lower Emory River tributary, in 2004 (C.F. Saylor, TVA retired, pers. comm., 2009) and two more individuals there in 2005 (Russ 2006). A single Spotfin Chub was also sampled in Crab Orchard Creek in 2007 (C.F. Saylor, TVA retired, pers. comm., 2009). Tributary streams in the drainage are prone to being intermittent, thus limiting Spotfin Chub habitat in all but their lowermost reaches, and probably accounting for the sporadic nature of small tributary records (Russ 2006). Sampling in 2004–2005 determined that the range of Spotfin Chub in the drainage contracted slightly relative to data reported in the Recovery Plan. Occupied range in Emory River expanded 3.4 RMs while range contracted in Clear Creek and Daddys Creek by 3.4 and 2.0 RMs, respectively (Russ 2006).

Jenkins and Burkhead (1980) posited that Spotfin Chub in the Emory River drainage population cluster was "more common" when comparing abundance to North Fork Holston River and Little Tennessee River population clusters. At present this population cluster is probably secondary in overall abundance to the Little Tennessee River population. However, nearly 90% of Spotfin Chub abundance observed in this cluster was from just three lower Emory River sites where it is generally distributed and relatively common (Russ 2006). Spotfin Chub is primarily occasional or sporadic in distribution and uncommon or rare outside of this reach. Occurrences in tributaries to Emory River are probably dependent on the strong source population in the lower main stem for sustainability.

Portions of this population cluster are susceptible to coal mining activities, oil and gas exploration, sedimentation from agricultural and general developmental activities, water withdrawals, and eutrophication from outdated wastewater treatment plants (Russ 2006). The appearance of a non-indigenous aquatic plant, Hydrilla (*Hydrilla* sp.), warrants monitoring (C.F. Saylor, TVA retired, pers. comm., 2014). Most impacts appear to originate from headwater streams. Population status is considered stable (Russ 2006; C.F. Saylor, TVA retired, pers. comm., 2009, 2014).

Little Tennessee River drainage, North Carolina and Tennessee: Little Tennessee River is a major tributary of upper Tennessee River. Headwaters are in northern Georgia and western North Carolina with its lower watershed in eastern Tennessee. It drains primarily the Blue Ridge Physiographic Province with the lower portion of the drainage occurring in the Ridge and Valley Physiographic Province.

Historically, Spotfin Chub was known from the main stem and some large tributaries in the lower part of the watershed. This drainage likely harbored large expanses of habitat in much of the middle and lower main stem and larger tributaries prior to impoundment. Today, the entire reach downstream of Fontana

Dam, North Carolina, is a coldwater river segment due to hypolimnetic releases from the huge dam and further dammed once again in North Carolina (Cheoah Dam) and three more times in Tennessee (Calderwood, Chilhowee, and Tellico dams) until it reaches Tennessee River. At the time of the recovery plan, only a ~23-RM reach of upper Little Tennessee River between Franklin Dam and Fontana Reservoir sustained a population of the species in this drainage. Seasonal occurrences (generally fall) of primarily juvenile and subadult Spotfin Chub are now known from 11 tributaries in this reach (McLarney 2007). These include Bradley Creek, Burningtown Creek, Brush Creek, Cowee Creek, Iotla Creek, Lakey Creek, Rattlesnake Creek, Sawmill Creek, Tellico Creek, Watauga Creek, and Wiggins Creek. These records are mostly from the lowermost reaches of these streams. It is possible these individuals may be searching for appropriate habitat as young fish disperse throughout the main stem river and tributaries. Other historical tributary populations of the species are now considered extirpated (e.g., Citico Creek, Abrams Creek, Tuckasegee River).

Two other streams in the lower Little Tennessee River drainage are undergoing attempts to establish Spotfin Chub populations: Tellico River, Tennessee (Petty et al. 2014), and Cheoah River, North Carolina (S.J. Fraley, NCWRC, pers. comm., 2009) (also see section II.B.3. Recovery Criterion 2). Though no historical records for the species exist in these streams, some habitat has been located and records are available from nearby tributaries. Introductions began in 2002 but it was not until the last few years that Spotfin Chub in Tellico River appears to be flourishing with evidence of recruitment, though the total extent of suitable habitat appears to be limited. The first fish were translocated in 2009 in Cheoah River, and the species appears to be thriving, with ample recent observations of adults and juveniles particularly upstream and to a lesser extent downstream from the two points of release. Though a self-sustaining population may already have been established in Cheoah River, several more years may be needed to determine success in Tellico River. Regardless of current population status, close monitoring of the species in both rivers should continue to accurately assess population establishment success. The introduction reach in Cheoah River is downstream of Santeetlah Dam, representing the only population within the species' current range—natural or otherwise—that is a tailwater. If successful, this population restoration may have significant management implications for other potential tailwater reintroductions (e.g., Cherokee Dam on Holston River, Douglas Dam on French Broad River).

A third stream in the watershed, Abrams Creek, Tennessee, site of historical collections, was also the focus of a reintroduction effort beginning in 1988. However, after ~15 years of releases, the project was terminated when no evidence of an established population was apparent (George et al. 2009). It is likely that the reach of seemingly suitable habitat in the creek was not of a sufficient extent or quality to sustain a Spotfin Chub population. Further, for long-term viability of the species was probably dependent on a now extirpated population in the main stem of lower Little Tennessee River.

Spotfin Chub is generally distributed throughout most of the ~23-RM reach of upper Little Tennessee River between Franklin Dam and Fontana Reservoir but is occasional to sporadic in larger tributaries. This population cluster represents one of the largest habitat patches known rangewide. Abundance was reported as "generally uncommon to rare" in the late 1970s according to Jenkins and Burkhead (1980). By the mid to late 1980s, the population was thought to have increased substantially (Alderman 1987; McLarney 1989, 1990). Limited sampling in the 1990s to early 2000s indicated a relatively sizable population persisted in the reach. By 2005 the population appeared to have declined noticeably (Russ and Fraley 2011).

A rigorous 10-year quantitative sampling regime of parallel transects at 10 sites in the reach augmented by qualitative sampling (timed searches) was initiated by NCWRC in 2007 to meet Recovery Criterion 2 in the Recovery Plan (T.W. Russ, II, NCWRC, pers. comm., 2014; see section II.B.3.). All 10 sites were scheduled to be sampled the 1st and 10th year of the study with 5 sites to be sampled on an alternating basis in the intervening years. Data accumulated until 2009—encompassing two time periods at each site—indicates the population increased in the study reach to the point of being common or even relatively abundant at some sites. Population numbers remained strong from 2010–2012, but in 2013 unusually high water persisted throughout the warmwater season, apparently contributing to substantially reduced numbers of both adults and juveniles. The species appears to be more abundant in the lower portions of the reach where the river is wider and offers considerably more and larger habitat patches than in the upstream reaches. Little Tennessee River likely harbors the largest among the four Spotfin Chub population clusters.

Though the species is known from several small streams in this drainage cluster, Spotfin Chub in tributaries are undoubtedly dependent upon the main stem population for sustainability (e.g., Jenkins and Burkhead 1982, 1984). It is therefore unlikely that small tributary occurrences of this species would be self-sustaining if the main stem population was totally lost from an extreme stochastic event. Threats include operation of Franklin Dam, runoff from construction and other development associated with a growing human population in the upper watershed, and general sedimentation. Population status appears to relatively stable over the past several years (W.T. Russ, II, NCWRC, pers. comm., 2014).

Buffalo River, Tennessee: Buffalo River is the largest tributary of Duck River, and occurs in the lower portion of the latter drainage in southwestern Tennessee. The Buffalo River watershed is located completely within the Western Highland Rim Subsection of the Interior Low Plateaus Physiographic Province.

At the time of the Recovery Plan, Spotfin Chub was known only from Buffalo River near the mouth of Grinders Creek (1978) and a single record in Grinders Creek (1937). No individuals have been found in Grinders Creek since 1937 though a few have since been found over the past several years at Buffalo River main stem sites from Grinders Creek upstream to the vicinity of Natchez Trace Parkway, extending its known range ~9 RMs upstream (P.L. Rakes, CFI, and R.B. Johansen, Austin Peay State University, pers. comm., 2013). A personal communication with B.M. Burr in Boschung and Mayden (2004) also places it in Duck River—parent stream to Buffalo River—but without locality data. This occurrence has not otherwise been documented in the literature nor with museum vouchers and is therefore not accepted in this assessment.

Spotfin Chub in Buffalo River represents the smallest and most imperiled population rangewide due to its sporadic distribution, rarity, and being restricted to a <9-RM reach of river. The restricted nature of this population cluster makes it the most likely to suffer extirpation from a stochastic event. In addition to stressors associated with small isolated populations, threats include sedimentation and agricultural runoff. Given the persistence of this population (records from as late as 2012) and water quality improvements in the Buffalo River, the population is currently considered stable (C.F. Saylor, TVA retired, pers. comm., 2014).

In summary, the long term trend (century or more) for Spotfin Chub rangewide is obviously declining. However, the current overall status of the species has improved over the past several years as indicated primarily by data from the Emory River and Little Tennessee River population clusters and range expansion in the Holston River population cluster.

b. Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
It is likely that given its large stream habitat, the entire Tennessee River drainage historically represented a single Spotfin Chub metapopulation. Habitat alteration began on a grand scale with logging, mining, and early industrial activities throughout the Tennessee Valley during the 1800s and early 1900s. Impacts to riverine habitat continued and were profound during the large reservoir construction boom of the early and mid-20th century (Haag 2009). Additional reaches of habitat became unsuitable due to contaminants during this period (Jenkins and Burkhead 1982, 1984). By the mid- to late 1900s, these activities had collectively reduced Spotfin Chub to the four population clusters currently known.

Since a rangewide population genetics study of the species has not been conducted, there is little empirical information on genetic structure of Spotfin Chub populations to delineate levels of genetic isolation and phylogenetic relationships among populations. However, the four extant population clusters of the species occur in each of the four Physiographic Provinces of historical occurrence. Many endemic stream fishes exhibit physiographic integrity, so it is important to maintain their genetic integrity (e.g., George et al. 2009). Spotfin Chub have been cultured for >20 years at CFI. Culturists and managers are aware that each population cluster may represent a unique genetic stock. Each stock in captivity is isolated and considerable care is taken to use appropriate stocks when conducting population augmentations and reintroductions within its historical range.

An effective population size (EPS) is required to maintain genetic heterogeneity and population viability (Soulé 1980). Isolated populations eventually die out when population size drops below the EPS or threshold level of sustainability. Due to barriers to genetic interchange from habitat destruction, small isolated populations (e.g., Spotfin Chub in Buffalo River) are at a greater risk of extirpation. Fragmented habitats and isolated populations of organisms may suffer the effects, to varying degrees, of genetic isolation (e.g., reduced genetic variation, genetic drift, inbreeding depression).

The phenomena that lend themselves to extirpation of species in small isolated habitat patches may have contributed to the loss of Spotfin Chub in various smaller tributary streams, such as Whites Creek, an upper Tennessee River tributary in eastern Tennessee. The lower portion of this small stream was impounded in 1942 by Watts Bar Dam on the Tennessee River. The species was not discovered until 1959 when seven specimens were sampled (Jenkins and Burkhead 1982, 1984). Repeated efforts to find the fish since 1959 have proven futile. Only a few miles of the main stem of Whites Creek were left unimpounded downstream of a network of small headwater tributaries, leaving a very small habitat patch in which the species attempted to maintain viability. That Spotfin Chub continued to survive for at least 17 years is astonishing given the small, disjunct habitat patch and its short life span. The population may have been relatively sizable to persist nearly two decades in Whites Creek. Ultimately, without a source population to sustain it, the species may have been doomed in the stream when it dropped below the level of sustainability.

An intergeneric hybrid specimen representing a cross between Spotfin Chub and Whitetail Shiner was reported from Daddys Creek by Burkhead and Bauer (1983). Whitetail Shiner is a common cyprinid whose range completely overlaps that of Spotfin Chub, and the two species are often observed in the same foraging schools (pers. obs.). This hybrid cross appears to indicate a relatively close relationship between the genera *Erimonax* and *Cyprinella* (Etnier and Starnes 1993; Jenkins and Burkhead 1993; Boschung and Mayden 2004).

c. Taxonomic classification or changes in nomenclature:

Recognition of Spotfin Chub as a distinct species within the minnow family Cyprinidae has never been a taxonomic issue. The species has never been synonymized under another taxon and is lacking a synonym (Jenkins and Burkhead 1982, 1984). However, generic placement of Spotfin Chub has perpetually confounded ichthyologists and has therefore changed frequently since its original description. Cope (1868) described Spotfin Chub as *Ceratichthys monachus*, using, at the time, the now synonymized genus that included most eastern barbeled minnows (R.E. Jenkins, Roanoke College, retired, pers. comm., 2009). Jordan (1924) created the genus *Erimonax* and placed in it only Spotfin Chub. Since 1924, Spotfin Chub has also been considered a species of the genera *Hybopsis* (Jenkins and Burkhead 1982, 1984; Recovery Plan; Menhinick 1991), *Erimystax* (Mayden 1989), and *Cyprinella* (Etnier and Starnes 1993; Jenkins and Burkhead 1993; Boschung and Mayden 2004), while *Erimonax* was retained by Mayden et al. (1992). *Erimystax* has also been considered a subgenus of *Hybopsis* (Jenkins and Burkhead 1982, 1984). The species has also been referred to as Turquoise Shiner (e.g., Jenkins and Burkhead 1993), which would have been highly appropriate as a common name given the startling electric hues of nuptial males. The names committee of the American Fisheries Society currently considers *Erimonax* to be the appropriate generic name for this species and Spotfin Chub as the official common name (Page et al. 2013). As currently recognized, the genus *Erimonax* contains only Spotfin Chub and is therefore monotypic.

d. Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g. corrections to the historical range, change in distribution of the species' within its historical range, etc.):

Spotfin Chub generally occurs in large upland streams in the Tennessee River drainage. The Recovery Plan stated that Spotfin Chub was known from at least 23 streams in 12 tributary drainages located throughout most of this drainage, occurred in four of five physiographic provinces (all but Coastal Plain) comprising the watershed, and five states (Jenkins and Burkhead 1982, 1984). By drainage, these include Holston River drainage (North Fork Holston River, South Fork Holston River, Jacob Creek), French Broad River drainage (Swannanoa River, Spring Creek), Clinch River drainage minus Emory River drainage (Clinch River, Indian Creek, Ball Creek), Emory River drainage (Emory River, Island Creek, Obed River, Clear Creek, Daddys Creek), Little Tennessee River drainage (Little Tennessee River, Tuckasegee River, Abrams Creek, Citico Creek), Duck River drainage (Buffalo River, Grinders Creek), and other direct tributaries of Tennessee River (Whites Creek, South Chickamauga Creek, Little Bear Creek, Shoal Creek). Most records are from the upper portion of the Tennessee River drainage and primarily represent larger streams draining the Ridge and Valley and Blue Ridge Physiographic Provinces. A significant positive correlation between increasing drainage size and Spotfin Chub occurrence was determined in the Emory River population cluster (Russ 2006).

Due to long-term populations losses, in the early 1990s Etnier and Starnes (1993) considered Spotfin Chub to be "apparently disappearing from [the Tennessee state fish] fauna." Recent sampling efforts since then and a more thorough search of historical records from the literature and museums brings the total number of streams having Spotfin Chub records to 41 with the addition of Holston River, Middle Fork Holston River, 3 small tributaries of North Fork Holston River (Wolf

Creek, Opossum Creek, Terrill Creek), 2 small tributaries of Emory River (Crab Orchard Creek, Clifty Creek), and 11 small tributaries of Little Tennessee River (Bradley Creek, Burningtown Creek, Brush Creek, Cowee Creek, Iotla Creek, Lakey Creek, Rattlesnake Creek, Sawmill Creek, Tellico Creek, Watauga Creek, Wiggins Creek) none of which were recorded at the time of the Recovery Plan (Russ 2006; McLarney 2007; C.F. Saylor, TVA retired, pers. comm., 2009).

In all, at least 16 streams are considered to have lost their Spotfin Chub populations. These include Holston River drainage (South Fork Holston River, Middle Fork Holston River, Jacobs Creek), French Broad River drainage (Swannanoa River, Spring Creek), Clinch River drainage (Clinch River, Ball Creek, Indian Creek), Little Tennessee River drainage (Tuckasegee River, Abrams Creek, Citico Creek), Duck River drainage (Grinders Creek), and other small tributaries of Tennessee River (Whites Creek, South Chickamauga Creek, Shoal Creek, Little Bear Creek). Due to extirpations, only four population clusters have persisted since 1960. These include Holston River drainage, Emory River drainage, Little Tennessee River drainage, and Buffalo River. Interestingly, the four extant population clusters of Spotfin Chub occur in each of the four physiographic provinces of historical occurrence (Ridge and Valley, Blue Ridge, Appalachian Plateaus, and Interior Low Plateau).

Spotfin Chub likely also occurred in several other streams in the Tennessee River drainage but may have been overlooked due to prior lack of fish collections or its rarity and occurrence at undetectable levels (e.g., Jenkins and Burkhead 1982, 1984). The species must have occurred in parent streams with known records from tributaries thereof (e.g., Tennessee River, French Broad River, Powell River, Sycamore Creek, Duck River) and may have occurred in other streams as well (e.g., Pigeon River, Nolichucky River, Hiwassee River, Elk River). These streams are now largely impounded behind TVA reservoirs or have experienced habitat alteration from pollutants, resource extraction activities, and various other sources over the past century. Numerous sites in these streams have been surveyed without finding evidence of Spotfin Chub. It is possible the Spotfin Chub records known from near the mouths of several smaller tributary streams (e.g., Whites Creek, Shoal Creek, Little Bear Creek) were simply part of a hypothetical main stem Tennessee River population of this species. When the source population in Tennessee River was lost due to impoundment, these sink populations became extirpated (e.g., Jenkins and Burkhead 1982, 1984). Large impoundments have clearly isolated all population clusters from one another.

The loss of Spotfin Chub populations from streams where it has become extirpated combined with extensive reaches of degraded and now unsuitable habitat in streams which continue to harbor extant but reach-limited populations (e.g., Buffalo River, Little Tennessee River, Holston River) indicates that a considerable extent of its former distribution—potentially a few hundred stream miles—has likely been lost rangewide. The loss of certain stream populations has caused Spotfin Chub to become extirpated from Alabama (Boschung and Mayden 2004) and Georgia (Jenkins and Burkhead 1982, 1984).

Spotfin Chub is generally sporadic or occasional in distribution and usually occurs at varying levels of abundance from very rare to relatively common in discrete reaches in most streams of occurrence. Only in select stream reaches (e.g., lowermost Emory River, upper Little Tennessee River) is the species considered generally distributed in occurrence and may approach relatively abundant at a few select sites. In addition, occurrences in small tributaries in three of four population clusters (except Buffalo River) are highly sporadic or may be seasonal. Overall stream miles inhabited by the species in 1983 was estimated to be 103 RMs, However, inhabited stream miles have increased primarily due to apparent population expansion in the Holston River drainage and seasonal occurrence in several small tributaries of upper Little Tennessee River. Total stream reaches of occurrence now total ~155 RMs (not including the lower ends of several small tributaries), though Spotfin Chub may be highly sporadic in occurrence in some longer reaches (e.g., middle North Fork Holston River).

Two streams of historical distribution have been the focus of recent reintroduction efforts for Spotfin Chub. A reintroduction attempted in Abrams Creek beginning in the late 1980s was recently deemed unsuccessful (George et al. 2009). However, conservation biologists are releasing laboratory-cultured Spotfin Chub in Shoal Creek in a continuing effort to reestablish a population of the species in the NEP designated there; ~22,000 individuals have been released through 2013 using broodstock from Emory River (Petty et al. 2014). Two streams with no historical Spotfin Chub records, but clearly within the range of the species and having habitat deemed suitable to support the species, are the focus of ongoing population establishment efforts. These include Tellico River, another NEP where ~19,000 cultured individuals have been released from 2002–2013 (Petty et al. 2014), and Cheoah River, where ~2,200 primarily cultured juveniles as well as some translocated adults have been introduced between 2009 and 2013 (W.T. Russ, II, NCWRC, pers. comm., 2014). Though a self-sustaining population may already be at hand in Cheoah River, close monitoring is warranted there and in Tellico River for several years to come to insure population viability has occurred. Both rivers have limited reaches of suitable habitat making their Spotfin Chub populations highly susceptible to stochastic events. It may take several more years of regular stockings of cultured fishes in Shoal Creek to determine if establishment of a self-sustaining Spotfin Chub population is possible there.

e. Habitat:

Spotfin Chub typically inhabits moderate runs over bedrock, large boulders, and other substrates in large, clear, upland streams. Spawning and foraging substrates must be swept relatively free of fine sediments. In winter, the species may move to pools with sand bottoms (Russ 2006). Both spawning (e.g., a crevice spawner requiring relatively silt free sites) and foraging behavior (e.g., a benthic insectivore) clearly indicate that it is much more of a habitat specialist than other members of its family. These attributes, coupled with habitat fragmentation and population isolation, contribute to an elevated level of imperilment for fishes such as Spotfin Chub (Neves and Angermeier 1990; Angermeier 1995; Burkhead and Jelks 2001).

The construction of major impoundments in much of the range of Spotfin Chub contributed heavily to habitat alterations for the species and resulted in highly disjunct current populations (Neves and Angermeier 1990). Additional losses were likely realized from contaminants, sedimentation, and other habitat alterations (e.g., middle North Fork Holston River). Losses from these sources were such that current habitat levels represent but a small percentage of historical habitat available for the species.

Improving or protecting habitat in larger streams frequented by Spotfin Chub is more problematic than these efforts in smaller streams since habitat in larger streams is influenced by more widespread conditions in the watershed. Therefore, traditional riparian habitat restoration efforts may be important to conduct in headwater streams for reducing sedimentation impacts to the fish and its habitat in downstream areas. Activities that fail to maintain riparian buffers in Spotfin Chub streams and upstream tributary reaches and allow sedimentation and pollutants to enter streams have the potential to impact populations. Various governmental agencies, non-governmental organizations, corporate and private landowners, and other partners are collaborating to protect water and habitat quality in various streams with extant Spotfin Chub populations.

Some dam operations may affect Spotfin Chub populations or impact regulated river reaches where there is a potential for reintroductions. However, there are means for improving dam discharges and TVA is improving tailwater conditions downstream of certain dams in the Tennessee River drainage that benefit riverine fishes (Layzer and Scott 2006; see section II.C.2.a.). Further, partners are collaborating with FERC, U.S. Army Corps of Engineers, and power companies on upgrading discharges to improve fish habitat in other, non-TVA tailwaters.

Some threats to the species and its habitat are virtually impossible to control. The probability of stochastic events like chemical spills or extended droughts altering its habitat and harming or killing individuals are ever present. Numerous roads, railroads, and pipelines that parallel and cross streams with Spotfin Chubs or in upstream areas of their watersheds are potential access points for toxicants that could decimate their habitat and populations.

f. Other:

Though development of propagation technology for initiating population restoration efforts was not specifically mentioned in the recovery plan, these activities are likely the best way to recover fish species, given adequate habitat conditions in which to conduct population restoration activities. At the time of the Recovery Plan, there were no non-game fish culture facilities in the Southeast. Since that time, CFI was established in Knoxville, Tennessee, specifically to culture imperiled fishes for population restoration activities. Their developing knowledge in culturing Spotfin Chub, in collaboration with other partners, has made it possible to produce large numbers of the species for population restoration efforts. As a result of these activities, some stream populations are in the act of being reintroduced (see section II.C.1.a.) while reintroductions are being considered in other streams using propagated individuals.

Spotfin Chub culture and population restoration plans should be completed prior to implementation of recovery actions. Extreme care must be given to population genetic considerations and other factors so as not to cause harm to broodstock source and reintroduced/augmented populations, ecological relationships in recipient waters, and to resident fishes of other species (Epifanio et al. 2003; George et al. 2009).

There was much discussion among resource managers and fish experts as to which criteria should be paramount in choosing a source population for reintroduction efforts in Shoal Creek since no obvious source was available, as in other reintroductions. Ultimately, Emory River broodstock was chosen due to replicated patterns of biogeography (based on molecular phylogenies and gene flow) exhibited by several other benthic fishes in the middle Tennessee River drainage (where Shoal Creek drains) and upper Tennessee River drainage (where Emory River drains) (George et al. 2009). Several individuals argued that the adjacent Buffalo River population should have been used since the habitat is very similar in the two drainages, both streams occupying Highland Rim subsection of the Interior Low Plateaus Physiographic Province (Emory River lies in the Appalachian Plateaus Physiographic Province). Habitat conditions might be a better criterion to consider when deciding a broodstock source, and it is possible that one reason the Shoal Creek reintroduction effort does not appear to be very successful to date is that an inappropriate broodstock source was chosen. If continued releases and monitoring of this population continue to show little sign of success, resource managers need to seriously consider changing the source of broodstock to Buffalo River in a continuing attempt to reestablish a Shoal Creek population of Spotfin Chub.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

The Recovery Plan listed nine "anthropogenic and natural limiting factors on all known populations" of Spotfin Chub and divided them into direct and indirect impacts for each extant and extirpated population (tabularized in Jenkins and Burkhead 1982, 1984). These included: 1) impoundment, 2) cold tailwaters, 3) channelization, 4) siltation and/or coal fine sedimentation, 5) pollution (inorganic and/or organic), 6) population renovation, 7) localized collecting, 8) natural cool temperature, and 9) small stream size. Direct and indirect impacts to currently extant populations were 8 (Buffalo River); 1, 2, 4, 5, and 8 (Little Tennessee River); 1, 4, and 5 (Emory River drainage); and 4, 5, and 7 (North Fork Holston River). Some of these threats that were not elaborated upon in the Recovery Plan or that are deemed to be continuing threats are summarized under the appropriate headings below.

a. Present or threatened destruction, modification or curtailment of its habitat or range:

The Recovery Plan included impoundments, cold tailwaters, channelization, siltation/coal fines, and pollution as having affected Spotfin Chub populations. Some of these issues warrant readdressing herein.

Large hydropeaking and flood control dams and their resulting impoundments probably contributed to the extirpation of more Spotfin Chub populations than any other factor. Thirteen stream populations were considered to have been either directly or indirectly influenced by construction of dams and impoundments (Jenkins and Burkhead 1982, 1984). Many others were likely lost. Cold tailwaters may have played a major role in the extirpation of other populations (e.g., lower South Fork Holston River, lower Clinch River, lower Little Tennessee River). At the time of the 1983 Recovery Plan, the major dam construction phase in the eastern United States had come to an end (Haag 2009). Approximately 40% of larger stream habitat had been altered under reservoirs or in dam tailwaters in the upper Tennessee River drainage (Neves and Angermeier 1990), the heart of the historical range of Spotfin Chub. Typical flow and water quality characteristics of many large dam tailwaters (e.g., low temperatures, depressed oxygen levels, lack of minimum flows, bank failures and substrate instability from hydropeaking) alter habitats and make them unsuitable for many species of riverine fishes like Spotfin Chub.

A single population of Spotfin Chub, the reintroduced population in Cheoah River, occurs in tailwaters. There is the potential to reintroduce the species to other tailwaters, especially French Broad River downstream of Douglas Dam, and Holston River downstream of Cherokee Dam, both in Tennessee. These tailwaters were designated NEP reaches in 2007 for Spotfin Chub and several other fishes and mollusks (72 FR 52433–52461). Some alterations have been made to TVA dam releases to improve habitat in these tailwaters (e.g., increasing temperatures through multiport releases, increasing oxygenation with aerators, establishing minimum flow schedules, reducing or eliminating hydropeaking). However, conditions in Douglas tailwaters Dam are thought to remain suboptimal for many fishes in general and cyprinids in particular due to the project being a peaking hydroelectric facility (Layzer and Scott 2006). During peak power generation there is a dearth of flow refuges and bank-full flows eliminate most shallow water habitats for young fishes. Releases will require further modifications to produce habitat conditions conducive for Spotfin Chub to thrive. If flows are restored, a dewatered reach of the Hiwassee River in Tennessee downstream of Appalachia Dam may also provide habitat for the species.

Landscape scale habitat degradation, like impoundments, is largely a legacy issue. However, some Spotfin Chub populations appear to be suffering from ongoing habitat degradation due the continuing impacts of landuse practices causing sedimentation. Sources include agriculture, mining, developmental activities, and unprotected riparian areas. A study conducted on Little Tennessee River Spotfin Chub concluded that sedimentation had sublethal effects on the fish. Laboratory experiments determined that growth rate at all life stages, spawning success, and gill condition was negatively correlated with sedimentation levels and that stress levels were positively correlated with sediment (Sutherland 2005; Sutherland and Meyer 2007). Respiratory impairment was determined to be one mechanism resulting from the negative impacts upon stream fishes from excessive sedimentation. Further, reduced growth rates affect fitness, survivability, and year-class strength by reducing recruitment. Similar effects of sedimentation disrupting spawning for other crevice-spawning shiners have been documented (Johnston 1999; Burkhead and Jelks 2001; Sutherland 2007). Sedimentation may also alter foraging habitat. Further, turbidity associated with elevated sedimentation levels may impede sight feeding fishes like Spotfin Chub (Jenkins and Burkhead 1982, 1984).

Coal mining was mentioned as a threat to certain populations in the Recovery Plan. Coal mining and oil and natural gas exploration in the headwaters of Emory River drainage is an ongoing threat to Spotfin Chub. Now extirpated Spotfin Chub populations in Clinch and Powell River drainages may have been affected by coal mining activities, though impoundment of Clinch River by Norris Dam inundated the only known population from the larger watershed.

Contamination by mercury and other toxicants from an industrial site spanning a century polluted the entire reach of North Fork Holston River from Saltville, Virginia, downstream and continuing through Holston River—where it was augmented from several other sources and types of pollutants—to Cherokee Reservoir, a distance of ~100 RMs downstream (Neves and Angermeier 1990). Sediments in some reaches may continue to be toxic due to this chronic event, though recent population expansion in the river may indicate that habitat and water quality is improving (see section II.C.1.a.).

Bourgeoning human population growth is taxing surface waters in many areas. Water withdrawal is increasingly threatening aquatic resources in many regions of the country. This issue is of particular concern in the Emory River watershed which drains the Cumberland Plateau (W.T. Russ, II, NCWRC, pers. comm., 2009). Water withdrawals may exacerbate the effects of droughts (Gagnon et al. 2004). Threats from water withdrawals include reducing habitat, decreasing the dilution factor for contaminants, increasing competition for spawning sites and foods, and increasing disease transmission (W.T. Russ, II, NCWRC, pers. comm., 2009). Other Spotfin Chub population clusters may also be threatened by water withdrawals at some time in the future. In fact, upper Little Tennessee River was recently considered for interbasin transfer of its waters in northern Georgia (S.J. Fraley, NCWRC, pers. comm., 2009).

An invasive aquatic plant, Hydrilla, has appeared in the Emory River drainage in recent years. Some pool areas in Clear Creek are essentially filled with the submergent vegetation. However, limited sampling by TVA has not shown any noticeable reduction in Spotfin Chub in the creek (C.F. Saylor, TVA retired, pers. comm., 2014).

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization for scientific purposes was identified as a localized threat in the North Fork Holston River in the Recovery Plan. This was based on information contained in Jenkins and Burkhead (1982, 1984) that suggested collections made by seining and the ichthyocide rotenone may have decimated localized populations in the stream. In addition, Spotfin Chub and many other rare fishes were eliminated from Abrams Creek in 1957 from a rotenone treatment to rid the stream of "rough fish" before being stocked by non-indigenous trout (Etnier and Starnes (1993). However, overcollecting is not currently considered a threat to the North Fork Holston River nor any other extant population of Spotfin Chub. Very few voucher specimens have been retained in recent decades due to the species' rarity and its status as federally threatened. Further, use of ichthyocides has largely ended, and focused efforts needed to capture Spotfin Chub reduce the likelihood that casual and unknowing collectors would take individuals.

A robust captive propagation program using wild-caught fishes as broodstock is underway at CFI to conserve Spotfin Chub populations (see section II.C.1.f.). Culturists are well aware of the rarity of the species and collection numbers are restricted by both federal and state permits. They use extreme caution in handling fish and when selectively collecting broodstock so as not to overly harm populations.

There is occasionally concern regarding the use of electro-shocking on small stream fishes (e.g., Reynolds 1996; Bohl et al. 2009). For instance, hemorrhage associated with the vertebral column has been associated with electrofishing in small stream fishes (Ruppert and Muth 1997; Cooke et al. 1998). A recent experiment on the effects of electroshocking specifically on Spotfin Chub determined no hemorrhaging in captive cultivated young fish and low stress-related mortality rates (Holliman et al. 2003). However, the authors urged the use of AC only in low-conductivity waters (<80 µS/cm) due to its well-documented risk to fishes (Reynolds 1996) and the minimum voltage regardless of waveform (AC, DC, or pulsed DC) needed to immobilize and capture shocked fish. A similar study using Spotfin Chub indicated that their embryos were particularly susceptible to commonly used DC currents (Bohl et al. 2009). The authors suggested that the use of electricity should be avoided around spawning sites and when embryos are present.

c. Disease or predation:

The Recovery Plan did not specifically discuss disease or predation as limiting factors for Spotfin Chub. We have no new information on disease that would indicate it is a limiting factor. However, the continued translocation of individuals and their cultured progeny across river basins by well-meaning managers undertaking population restoration actions is a concern with regard to the potential for transfer of diseases or parasites. For this concern, the use of broodstock from the same stream or drainage, if available, is preferred over interbasin transfers of fishes. Additionally, pre-release disease screening of propagated fishes should always be routinely conducted to ensure only healthy fish are stocked in the wild.

Whitetail Shiner has been observed preying on Spotfin Chub eggs (Sutherland 2005; Russ 2006). Several other fishes likely prey on Spotfin Chub during all life stages, but the level of predation is unlikely a significant threat to the species.

d. Inadequacy of existing regulatory mechanisms:

The inadequacy of existing regulatory mechanisms was not specifically considered to be a limiting factor in the Recovery Plan. Individuals are urged to implement best management practices to reduce the potential for altering riparian zones and stream habitats where Spotfin Chub occur.

e. Other natural or manmade factors affecting its continued existence:

The Recovery Plan mentioned natural cool temperature and small stream size as directly or indirectly affecting Spotfin Chub populations. Natural cool temperature was listed as possibly affecting two extant populations, Buffalo River and Little Tennessee River. The thriving natural population in Little Tennessee River makes this supposed threat unlikely but temperature is possibly a limiting factor for Spotfin Chub in Buffalo River. Small stream size was possibly a factor in several extirpated populations previously known from small tributary streams. Small streams may be unable to supply all of the ecological needs of this large stream fish. It is entirely possible that the loss of this species from several small tributary streams was inevitable due to the loss of a source population in a larger parent stream (e.g., Jenkins and Burkhead 1982, 1984). To this day Spotfin Chub occurrences in small tributaries in the Holston River, Emory River, and Little Tennessee River drainages are likely totally dependent upon source populations in their main stems for survival.

Climate change will potentially have significant effects on Spotfin Chub and its habitat. Species have evolved within a matrix of environmental conditions and some will perish if they are unable to adapt to altered conditions wrought by climate change (Larsen et al. 2005; Galbraith et al. 2010). Specific factors associated with climate change that may affect fishes have already begun in some cases and include changes in stream temperature regimes, timing and levels of precipitation, severity and frequency of floods and droughts, altered ranges, and changes in phenology (Ashizawa and Cole 1994; Parmesan 2006; Heino et al. 2009; Galbraith et al. 2010; International Panel on Climate Change 2013–2014). Higher temperatures, reduced precipitation and prolonged droughts should result in lowered dissolved oxygen (DO) and a potential reduction of suitable habitats for some aquatic organisms (Galbraith et al. 2010). Many riverine fish species may be unable to compensate for environmental changes due to their inability to migrate to more suitable waters due to barriers like dams and unsuitable habitat in impoundments (Strayer and Dudgeon 2010). Further, species like Spotfin Chub that have adapted highly specialized reproductive strategies may be particularly vulnerable to environmental changes (Kay 1995). Significant changes in factors like temperature and DO may have sublethal or even lethal effects on the species.

Stochasticity becomes an increasing threat to small, isolated, and declining populations of rare organisms (Lande et al. 2003). Two categories are evident: environmental and demographic. Environmental stochasticity includes both natural and anthropogenic factors that affect all populations similarly. Stochastic events, particularly chemical spills, are a constant concern for most rare populations of isolated aquatic organisms. Were it not for the fact that the species is relatively mobile relative to other small benthic fishes and can at least temporarily occupy small tributaries of core rivers of occurrence, stochasticity from toxic spills would be even more of a concern for their populations. Demographic stochasticity may negatively affect fishes when population parameters (e.g., availability of mates, fertilization and recruitment rates, fecundity) are highly reduced, potentially pushing imperiled species below the threshold minimum viable population size even in high quality habitats (Lande et al. 2003; Haag and Williams 2013). Each of these random processes may exacerbate the effects of the other in rare and declining populations (Haag 2012).

The Recovery Plan did not mention the deleterious effects of rarity, habitat fragmentation, and population isolation on imperiled species. Such species are always more susceptible to population extirpations and eventual extinction. Species that are restricted in range and population size are more likely to suffer loss of genetic diversity due to genetic drift, increasingly susceptible to inbreeding depression, and less likely to adapt to environmental changes (Allendorf and Luikart 2007). Spotfin Chub in Buffalo River is especially vulnerable to these effects. Once isolated Spotfin Chub populations are lost, the absence of an available source population makes recolonization impossible without human intervention (Sjögren 1991). Models predict that those species whose populations are fragmented and restricted to isolated habitat patches due to past habitat destruction are increasingly threatened with extirpation. Localized extirpations due to population fragmentation have a time lag during which species must pay an extinction debt sometime in the future (Tilman et al. 1994; Hanski and Ovaskainen 2002). Further, even good competitors and abundant species are susceptible to eventual extirpation from the extinction debt principle.

Competition was not noted as a threat in the Recovery Plan. However, Jenkins and Burkhead (1982, 1984) posited that its "competitive abilities...may be low." Competition for spawning sites with other crevice spawners (e.g., Whitetail Shiner) is a possible threat to Spotfin Chub (Sutherland 2005; Russ 2006). Spotfin Chub appears to be unaggressive and unopportunistic relative to other cyprinids with which it co-occurs (Jenkins and Burkhead 1982, 1984). This is a character trait that lends itself to imperilment (in combination with other threats), and may be an important factor in whether or not the species will be able to maintain a self-sustaining population in Shoal Creek, where there is the potential for competition with abundant populations of native cyprinids (J.R. Shute, CFI, pers. comm., 2014).

Benthic fishes such as Spotfin Chub are particularly susceptible to imperilment relative to those species that inhabit the water column or surface habitats (Warren et al. 1997). The preference for relatively sediment-free spawning crevices and foraging habitats (generally bedrock and boulders) makes Spotfin Chub a habitat specialist, another trait of imperiled fishes. The species also tends to be relatively poor at naturally expanding into suitable habitat based on observations in North Fork Holston River by Jenkins and Burkhead (1982, 1984).

D. Synthesis

This is the first 5-year review conducted for the Spotfin Chub. General threats to the species remain similar to what they were in 1977 when this species was listed as threatened in the Federal Register and to what they were in 1983 when the Recovery Plan was written. There have been few significant improvements regarding threats since 1983. However, the deleterious effects of habitat fragmentation and isolated populations, stochastic events, and climate change were not mentioned as threats to the species, and more detailed information is now available for several ongoing threats to the species. In addition, biological and distributional information that was not known when the Recovery Plan was written is now available, and includes observations on its spawning behavior, other details of its life history, and development of captive propagation technology.

Spotfin Chub is a rare large-stream fish that was widely distributed historically in most of the Tennessee River drainage. A total of 41 streams have records for the species, but at least 16 streams are thought to have lost their population. At present, four population clusters continue to support this species. Though no records are available, the species likely also occurred in reaches of the Tennessee River main stem and unknown populations were presumably lost in other larger streams in more upland portions of the Tennessee River drainage. Complete elimination from some streams combined with extensive losses in habitat from other fragmentally occupied streams indicates that hundreds of river miles of its total former range have been lost. This represents a substantial percentage of loss of range and abundance as well compared to historical levels of distribution and population size.

The total population size for Spotfin Chub, though undetermined, must be relatively small compared to historical levels. The Buffalo River and Holston River population clusters are both considerably smaller than those in Little Tennessee River and Emory River, though the species appears to be expanding appreciably in the Holston River drainage. Four streams within the historical range of Spotfin Chub have been the target of population reintroduction efforts since the late 1980s, with only Abrams Creek having failed. Though there is good evidence that the reintroduction efforts into Cheoah and Tellico rivers will be successful at establishing viable populations, continued monitoring over several more years will need to occur to determine if they are truly viable and self-sustaining. There is not enough evidence at this time to determine if ongoing reintroduction attempts in Shoal Creek will become successful at creating a self-sustaining population.

Compared to 40–50 years ago, Spotfin Chub has improved in overall conservation status. However, current data indicates that the species remains generally sporadic or occasional in distribution and occurs in discrete reaches in most streams of occurrence. Only in select stream reaches (e.g., lower Emory River, upper Little Tennessee River) is the species considered generally distributed and common in occurrence and abundance. All four Spotfin Chub population clusters are susceptible to various stressors, including the effects of habitat fragmentation and population isolation, and sedimentation, while general developmental activities (e.g., Little Tennessee River), coal mining and oil and natural gas exploration (e.g., Emory River), residual contamination (e.g., Holston River), and general rarity (Buffalo River) are also ongoing stressors. Further, the chance for a catastrophic stochastic event drastically affecting a population and its habitat is heightened in streams with limited habitat reaches, namely Buffalo, Cheoah, and Tellico rivers. A benthic habitat specialist, the species requires spawning and foraging sites swept relatively free of fine sediments. These biological and ecological attributes make this species more susceptible to habitat perturbations than most other stream cyprinids.

In summary, due to the status of the species in relation to the recovery criteria outlined in the Recovery Plan and the data and factors highlighted in this section, we recommend Spotfin Chub remain federally listed as a threatened species. However, updating the recovery criteria in the Recovery Plan to make them more quantifiable and achievable—including avoiding vague terminology like "location" and considering the overall expansion and current status of the species in each of the four population clusters—might demonstrate that the species no longer met the definition of a threatened species. If at least two of the ongoing population reintroduction efforts over the next few years become successful at establishing viable populations of the species, delisting Spotfin Chub may indeed be warranted.

III. RESULTS

A. Recommended Classification:

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__x_ **No change is needed**

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

Priority Actions:
* A species status assessment should be prepared to evaluate the species' status under the ESA and to help inform recovery planning prior to the development of the next 5-year review. This fish's Recovery Plan is over 35 year old and in need of revision. A revised plan will assist all partners, including state agency partners, in planning watershed and ecosystem recovery actions.
* Continue the 10-year monitoring program begun in Little Tennessee River in summer 2007.
* Initiate 10-year monitoring programs in North Fork Holston River, Emory River, and Buffalo River similar to the program that is ongoing in Little Tennessee River.
* Continue to augment, expand, and monitor potential new populations in Tellico River, Cheoah River, and Shoal Creek.
* Experimentally ascertain lethal and sublethal temperature and DO thresholds for both young-of-year and adult individuals of the species.
* Study the effects of dam releases on the species in Cheoah River and determine the feasibility of reintroductions in other tailwaters within its range.
* Survey streams where the species is considered extirpated or other large streams within its historical range and assess habitat conditions to determine the feasibility of population reintroductions.
* Conduct a population genetics study that specifically provides information critical for maintaining adequate levels of genetic diversity, particularly as they relate to hatchery-cultured individuals (e.g., population structure, gene flow, kinship).
* Reintroduce the species in streams within its historical range in reaches that have suitable habitat and water quality conditions. This may best be achieved through the propagation of juveniles. Broodstock should be carefully selected, and not based solely on genetics, but also on physical habitat, physiographic province, and nearest population.
* Continue to refine propagation technology for laboratory culture.
* Work with FWS Fisheries, academia, and other partners in conducting various aspects of propagation, reintroduction, and augmentation efforts, including funding for these activities.
* Determine the degree of threats to extant populations.
* Conduct a comprehensive rangewide taxonomic distinction study by analyzing various data sets (e.g., molecular genetics, microsatellites, meristics, morphometrics).
* Continue to work with FERC and other partners through the relicensing process in modifying the discharges of private dams to improve habitat conditions in tailwaters.
* Continue to work with TVA and other partners in modifying non-private dam discharges to improve habitat conditions in tailwaters. This is particularly important for potentially reintroducing populations in regulated rivers.

Other Actions:
* Conduct population viability analyses and study other aspects of demographics of significant extant populations (e.g., recruitment and mortality rates, sex ratios).
* Map suitable habitat patches using GIS technology and ground truth use of these habitat patches.
* Once suitable habitat patches are identified, use models to: 1) predict patch extent and location spatially and temporally and 2) conduct threat assessments of particular stressors to habitat patches.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Erimonax monachus*

Current Classification: Threatened
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__x__ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By: Bob Butler

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve JANET MIZZI Digitally signed by JANET MIZZI Date: 2019.06.13 11:38:03 -04'00' Date 6-13-19

REGIONAL OFFICE APPROVAL

Approve Franklin Arnold Date 6/27/19
Acting ARD - Ecological Services

for **Cooperating Regional Director, Fish and Wildlife Service**

X Concur ____ Do Not Concur

Signature Kyle J. Lastic Date 6-18-19
Acting ARD - Ecological Services

APPENDIX A: Summary of peer review for the 5-year review of Spotfin Chub (*Erimonax monachus*)

A. Peer Review Method:
This was not a PRB peer review. The author of this review selected five individuals that collectively had decades of experience with fish surveys and research and were well acquainted with Spotfin Chub, its habitat, and status. A memorandum was sent via email on June 17, 2014 to the peer reviewers soliciting their comments on a draft of the 5-year review. Comments from all five individuals were received by July 28, 2014.

B. Peer Review Charge:
Peer reviewers were specifically asked if they agreed with the scientific information that we compiled on the Spotfin Chub.

C. Summary of Peer Review Comments/Report:
All peer reviewers did not disagree with our assessments of population status. Some minor additional information on threats and population status was also received.

D. Response to Peer Review:
All comments and suggested edits were carefully considered and incorporated where deemed appropriate in the final draft of the 5-year review. Comments were generally in agreement with our assessments and other information contained in the document. No major concerns were voiced.